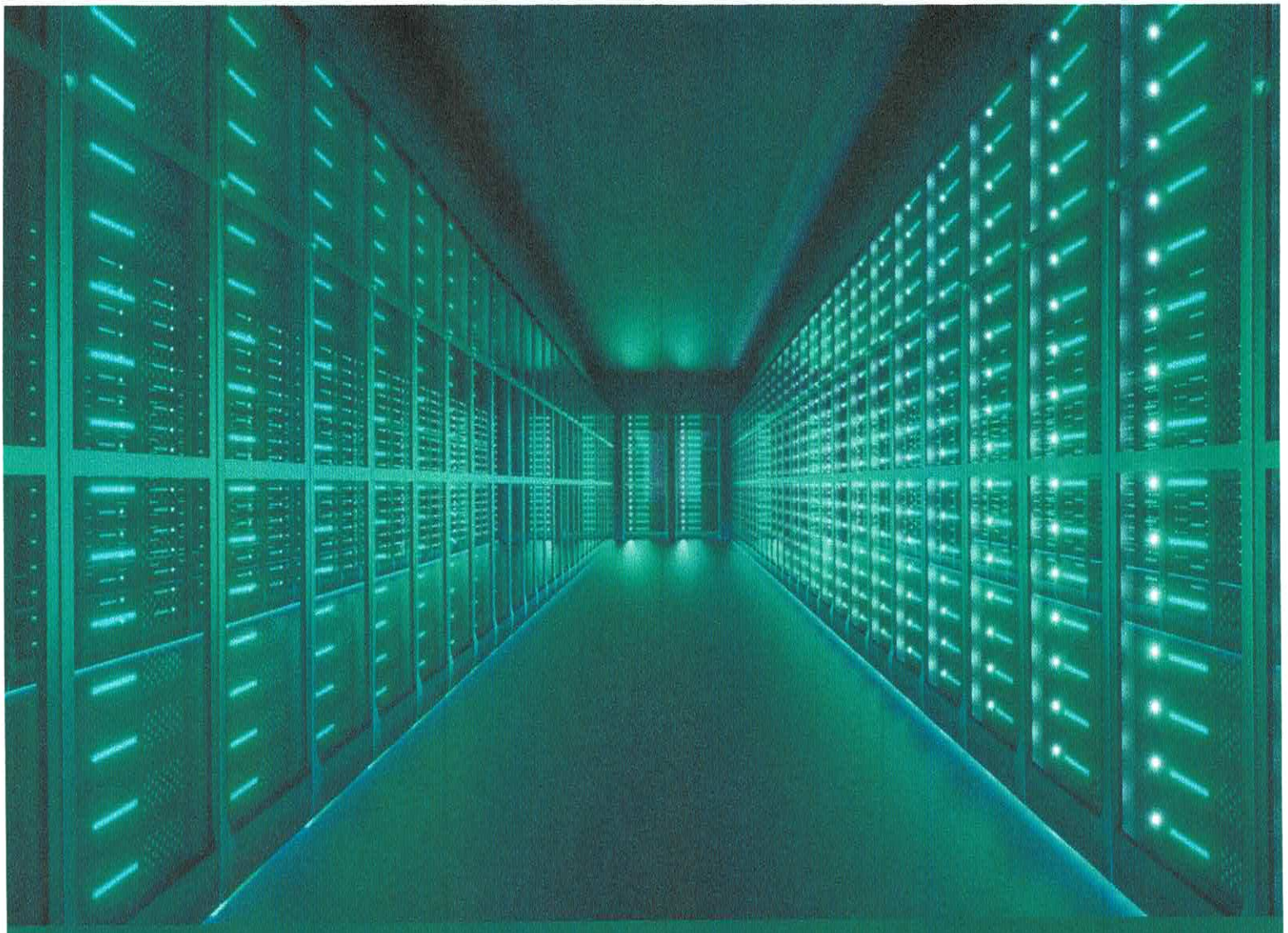

Green Horizon Report:

Extended Market Potential for Heat Capture from Data Centers

Sigmund Dahl Fiveland
Chief Technology Officer
Green Horizon AS
https://greenhorizon.no

Green Horizon
Data Center

Executive Summary

This report presents a revised analysis of the market potential for heat capture from data centers, considering two new dimensions that significantly increase its market potential.

This is in relation to the International Patent Application no.PCT/NO2024/050031 filed on February 12, 2024; *SYSTEM FOR AND METHOD OF HARNESSING HEAT GENERATED FROM RUNNING AT LEAST ONE VIRTUAL OPERATIVE SYSTEM INSTANCE.*

1. The initial market assessment focused solely on direct electricity savings, overlooking the potential value from high-quality heat-capture, i.e. providing hot water at more than 60 degrees Celsius for a wide range of industrial purposes.
2. The initial market assessment only focused on colder climates, whilst updated data shows that there is a broader global market potential that also includes the rest of the world.

This report shows that an average of 17,5% of the data center energy cost can be reduced by using heat-capture. In addition, the report shows that the market potential should be extended to cover the full global market.

By incorporating the additional value derived from high-quality heat capture and the expanded global market potential, the market potential is significantly higher than initially estimated and highlights a significant increase in the potential for increased revenue and broader market impact.

Background: Technology changes enables re-use of High-Quality Heat

A technological shift primarily involving much more energy-demanding components, such as 1300 watts NVIDIA Blackwell GPU, and two-phase DLC (Direct Liquid Cooling), along with software optimization of server utilization, now enables high-quality heat between 60 to 70 degrees Celsius.

Software optimization in data centres can lead to increased hot water production through its efficient management of server utilization. By constantly monitoring workloads, optimization software can identify servers operating at low utilization rates, which are inefficient. It can then consolidate these workloads onto fewer servers running at higher utilization rates, like concentrating work into a smaller, more efficient workspace. As tasks are transferred from underutilized servers, they can be shut down entirely, eliminating idle power consumption. With fewer servers running but at higher utilization rates, the remaining servers produce higher quality heat, typically ranging between 60 and 70 degrees Celsius.

Dimension 1: Value from High-Quality Heat Capture

The high-quality heat-capture potential (i.e. hot water which maintains a temperature of more than 60 degrees Celsius), has been undervalued in the initial assessment.

The excess heat generated in this process is highly versatile and can be directly utilized across numerous industries, including:

1. **Food Processing**: Utilized in cooking, blanching, or sterilization processes.
2. **Textile Industry**: For dyeing or washing processes.
3. **Chemical Industry**: In various chemical reactions or as a solvent.

4. **Pharmaceutical Industry**: For sterilization purposes or in manufacturing processes.
5. **Paper and Pulp Industry**: For paper drying or in pulp processing.
6. **Plastics Industry**: In extrusion processes or for heating during molding.
7. **Energy Generation**: Utilized in district heating.
8. **Metal Industry**: For metal treatment processes such as annealing or tempering.
9. **Laundry Services**: In commercial laundry operations.
10. **Hospitality Industry**: In hotels for laundry or kitchen operations.
11. **Agriculture**: For greenhouse heating or in agricultural processing.
12. **Waste Management**: In waste treatment processes such as anaerobic digestion.
13. **Aquaculture**: In fish farming operations for temperature control.
14. **Horticulture**: In greenhouse operations for temperature regulation.
15. **Biotechnology**: In fermentation processes or for maintaining specific environmental conditions.

The value of 60 to70 degrees Celsius hot water compared to the traditional temperature.

The value of hot water at 60 to 70 degrees Celsius, as compared to the standard 20 to 30 degrees Celsius, primarily lies in its thermal energy content. Here are the reasons:

1. **Energy Efficiency**: Industrial processes often require heat. If hot water is already at a high temperature (like 60 to 70 degrees Celsius), it can be used directly in heat-demanding processes or for pre-heating, thereby saving the energy that would otherwise be needed to heat the water from a lower temperature (like 20 degrees Celsius).
2. **Cost Savings**: Using high-temperature hot water can lead to significant cost savings. The cost of energy to heat water from 20 to 30 degrees Celsius to 60 to 70 degrees Celsius can be substantial, especially in energy-intensive industries.
3. **Environmental Impact**: Reusing hot water reduces the demand for fresh water. It also decreases the energy consumption associated with heating water and the greenhouse gas emissions that come from energy production.

The value of high-quality hot water can be calculated using the formula:
1 / COP + Power Grid Fee – Infra Capex (when comparing against an air to water heat pump in cold clime sone).

In Norway where electricity is cheap, this can be simplified to the fact that the consumer of the high-quality hot water will avoid the Power Grid Fee, which in Norway is approximately 0,30 NOK of the total cost per kWh of approximately 1 NOK. I.e. a saving of 30%.

Our data suggests that this high-quality hot water can be sold and leveraged for other industrial purposes, providing an equivalent value of between 5% and 30% of the input electricity cost. Therefore, an average of 17,5% reduction in the data center electricity cost should be incorporated into the valuation.

Dimension 2: Broader Global Market Potential

Our analysis indicates that the potential for hot water ranging from 60 to 70 degrees Celsius extends beyond colder climates to warmer regions as well.

This expanded potential can be attributed to three key factors:

1. **Versatility of High-Quality Hot water**: Hot water at 60 to 70 degrees Celsius has a much broader range of applications compared to water at the standard 30 degrees Celsius.
2. **Cooling Applications**: High-quality hot water can be effectively used for cooling, including the datacentres themselves, even in warmer climates.

Versatility of High-Quality Hot water

In addition to the summary of benefits described in "Dimension 1", one of the significant benefits of high-quality hot water is the option to avoid the use of evaporative cooling. Instead, Dry Cooling reduces water consumption by up to 40% compared to a conventional evaporative cooling system.

In warmer regions, water conversation is typically of key importance, emphasizing the significance of water reuse in regions where water is scarce.

Cooling in Warmer Climates

The concept of using hot water for cooling, particularly in temperate zones, may seem counterintuitive, but it can be quite effective under certain conditions. Here's a closer look at how this process works:

1. **Heat Pumps and Refrigeration Cycles**: Hot water can be used in systems like heat pumps that operate on the principle of moving heat from one place to another. In such systems, hot water can help transfer heat more efficiently from the environment or an object that needs to be cooled. The heat from the hot water is extracted by the heat pump and expelled to a cooler area, effectively cooling down the object or space in question.
2. **Thermal Energy Storage**: In some applications, particularly in building heating and cooling systems, hot water can be used as a thermal energy storage medium. During cooler times of the day, hot water can store excess heat generated by a building's heating system or by natural sunlight. This stored heat can then be used to warm the building during cooler periods, reducing the need for additional heating and effectively balancing the building's temperature.
3. **Absorption Refrigeration**: Another way hot water can contribute to cooling is through absorption refrigeration systems. These systems use a heat source, such as hot water, to drive a refrigeration cycle that cools down an environment. This is particularly useful in situations where excess heat (like solar heat or waste heat from industrial processes) is available and can be utilized to reduce the energy consumption of traditional electric refrigeration units.
4. **Enhanced Convection Cooling**: In certain industrial processes, hot water can help enhance the cooling of machinery or components by accelerating convection currents. When hot water flows through a system, it can encourage the faster movement of heat away from critical components, effectively cooling them by increasing the rate at which heat is dissipated into the surrounding environment.

5. **Increased free cooling possibilities in data centers:** Instead of using ice machines to leverage the heat to utilise dry coolers, the increased delta temperature makes it possible to use "free cooling" directly against the dry coolers. This enhances efficiency and reduces the power consumption of data centers, applicable in both warmer and colder regions worldwide. Furthermore, this also enables the use of dry coolers which removes the need for evaporative cooling, leading to a substantial decrease in water consumption—a critical consideration in many regions.

Water at 60 to 70 degrees Celsius is much more valuable than water at 20 to 30 degrees Celsius in several cooling applications for a few key reasons:

1. **Higher Efficiency in Heat Pumps**: In heat pump systems, the effectiveness of the heat transfer increases with the temperature differential between the heat source and the heat sink. Hot water at 60 to 70 degrees Celsius offers a larger temperature gradient compared to the surrounding environment than water at 20-30 degrees Celsius. This larger gradient allows the heat pump to operate more efficiently, transferring heat more effectively and enhancing the overall cooling process.
2. **Better Driving Force for Absorption Chillers**: Absorption chillers, which can be used to cool buildings or industrial processes, require a heat source to drive the refrigeration cycle. The efficiency of absorption chillers increases with the temperature of the heat input. Therefore, using water at 60 to 70 degrees Celsius provides a more effective and efficient driving force for the chiller compared to cooler water. This is because the higher temperature increases the vapor pressure in the absorption system, which is crucial for the refrigeration cycle's performance.
3. **Enhanced Thermal Storage Capacity**: Hot water at higher temperatures can store more thermal energy due to its higher heat capacity and temperature. This makes 60 to 70 degrees Celsius water more effective for use in thermal energy storage systems. Such systems can store this heat and later release it to either heat spaces when temperatures drop or continue driving processes that require thermal input during off-peak hours, thus maximizing energy usage and efficiency.
4. **Improved Performance in Industrial Processes**: In industrial settings, processes often require the input of heat to facilitate or speed up chemical reactions or other process elements. Water at 60 to 70 degrees Celsius can be used directly to input significant amounts of heat into these processes, making it more valuable than cooler water. Additionally, hot water can also be used to quickly bring other materials up to required temperatures, reducing processing time and energy consumption.
5. **Faster Heat Transfer Rates**: The rate of heat transfer in processes involving convection (like cooling through heat exchangers) is influenced by the temperature difference between the hot and cold fluids. Hot water at 60 to 70 degrees Celsius can more rapidly transfer its heat to a colder medium compared to 20 to 30 degrees Celsius water, making it more effective for rapid cooling where immediate large-scale heat dissipation is needed.

These methods highlight how hot water, typically seen as something that adds heat, can be strategically used to remove, or redistribute heat, thereby contributing to cooling processes in temperate zones. Thus, established technologies, including the refrigeration methods described above, can utilize warm water to cool facilities. Moreover, existing commercial products also offer solutions for generating new electricity from hot water, which might be applicable.

Recognizing these opportunities for waste heat reuse, the market potential is estimated to encompass the entirety of the global data center footprint. **Therefore, the market potential should be extended to cover the full global market.**

Date: 07.05.2024

Place: Sandnes

Signature: 

Name: Sigmund Dahl Fiveland

Title: Chief Technology Officer, Green Horizon AS